Public Comment to the Measuring Innovation in the 21st Century Advisory Committee, Economics and Statistics Administration, U.S. Department of Commerce

by

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My comments address the first and second themes in the call for comment. They will be included below under three main topics: 1) BEA should provide a finer level of detail to the public for the annual input-output accounts; 2) BEA and BLS should rethink the current methods of hedonic deflation of computers, semiconductors and other high-tech goods, as they distort the interpretation of constant price sectoral accounts in their current form; 3) BEA should shift emphasis from real value added to real gross output as a measure of industry growth.

Providing a finer level of industry detail in the industry accounts

BEA produces the annual IO accounts and the GDP by industry at a level of about 65 industries, 4 of which are government and government enterprises. For the study of many questions relating to R&D spending and innovation, this level of detail is not germane. For example, the Pharmaceuticals industry (NAICS 3254) is an extremely important industry for understanding the impacts of both basic and applied R&D spending. Plastics materials and resins (NAICS 325211) is another industry in which innovation has been occurring at a rapid pace. Petrochemicals (32511) and other basic organic chemicals (32519) are important to understanding the changing interindustry structure of the economy as ethanol and biodiesel fuels are more widely adopted. These three industries, as well as 22 others identified separately in the BEA 1997 benchmark IO table, are combined into one industry (Chemicals, or NAICS 325) in the Annual IO accounts, GDP-by-industry and other published BEA data. NAICS 334 (Computers and electronic products) on the other hand, are available in more detail from the BEA 65 sector release, with seven industries available.

BEA compiles these data internally at a much higher level of detail. I understand the rationale that BEA provides for only releasing the aggregate data. One important argument is that many of the source data are not reliable enough to support release of data at the more detailed level. Another is that the more detailed data may suffer from problems or inconsistencies that are not present in the more aggregate data. However, thousands of man-hours and millions of dollars have gone into developing the more detailed data, at BEA, the Census Bureau and other agencies. The annual IO accounts, and the R&D satellite accounts, may be viewed as the end product of many other statistical surveys and data releases, which have been collected at a high level of detail, partly due to the requirements and requests of BEA. Perhaps the data could be released

[1] This comment is from Academia. However, the comments are solely the opinions of the author, and are not implied to be endorsed by the University of Maryland.

with a disclaimer that they are not up to the usual high release quality of other BEA data. At any rate, the BEA detailed (unpublished) data, however imperfect it may be, is likely the best data to use for the study of innovation and productivity at the level of industries such as the Pharmaceutical industry. If BEA did not see fit to release the full 495 industry level of the benchmark table, perhaps something on the order of 150 industries might be possible. This would already represent a tremendous benefit to academic, business and government analysis of innovation.

Rethink the criteria for the development of hedonic price deflators for computers and other goods

No one would argue that we have not observed tremendous increases in the power and capacity of computers and their subsidiary components, such as semiconductors and storage media, over the past 20 to 30 years. The power of CPUs as measured by standard benchmarks, the storage capacity of hard drives per dollar, and the cost of memory per dollar are all examples of where the price of measured characteristics has continued to plummet, year after year. In some periods, such as the late 90s, these rates of price decline were as high as -35% per year. However, those who have used data deflated by these hedonic price indexes in a consistent constant price framework have observed several difficulties introduced by the rapidly declining price indexes:

1. Labor productivity and total factor productivity measures in the computer and related industries are almost entirely dominated by the rate of decline in the deflator. TFP growth in other industries may be understated, if the computer deflator is used to construct the real capital input of computers to those industries.
2. Changes over time in constant price input-output coefficients of the computer industry column are almost entirely dominated by movements in the computer deflator. Nominal measures of inputs to the computer industry change only gradually. However, if the real measure of output is growing rapidly due to a falling deflator, and the input prices are mostly rising, this means that all real IO coefficients in the computer column must be falling, due mainly to changes in the computer output deflator.
3. Measures of real value added, and the price of real value added, may be severely distorted. A larger share of the contributions to GDP growth is thereby attributed to the computer and related industries than many people would think is reasonable.

Furthermore, there are good theoretical arguments for believing that a deflator based solely on linear combinations of measurable characteristics of computers may not be the economically relevant price for many uses of computers. Here are some suggested reasons:

1. As the cost of the characteristics of computers (CPU Mhz, RAM, storage) falls, their marginal use value goes down as well. In other words, the utilization rate of those characteristics may decline almost in tandem with the increases in those characteristics. This is entirely rational, as consumers and business users equate

the marginal use value with the marginal cost. This argument was stressed by Gordon (2000) but has older roots.

2. The value of *capital services* from a dollar of computer investment is probably not increasing as much as the hedonically deflated constant price measure would indicate, and in fact may be increasing very little in most applications. In these applications, the computer must be combined with human labor input to produce these services. Although the computer no doubt increases the human's labor productivity, the human may put limits on the potential computer productivity. Again, this is rational, as the ratio of human to computer cost (measured in characteristics) is rising substantially over time.

3. When businesses make a decision to buy a capital good such as a computer, they base the decision on the nominal cost of that capital good at the current time, and implicitly make the decision to equate the shadow value of the new equipment to the user cost of capital. The shadow value of a quasi-fixed factor such as a computer is the marginal cost savings of variable factors such as labor and intermediate inputs. The user cost is directly proportional to the price. As the measured price falls, the measured increment to the capital stock of a given nominal amount of investment rises by the same proportion, so the shadow value of a certain nominal cost of computers should remain unchanged in equilibrium. This suggests that capital inputs of computers deflated hedonically are greatly overstating the effective contribution of computers to the savings of variable costs of other inputs. It is interesting in this regard to observe that nominal spending on computers has not changed greatly as a ratio of nominal output or total nominal investment over the last 25 years, which is consistent with this argument.

If the measured price of computers is not the economically relevant one, this will have the following results: 1) A naïve neoclassical growth decomposition will incorrectly attribute too much of the growth of the late 1990s to computers, as this was also a period when the computer deflator was falling the fastest; 2) An input demand function for computers will find a high, possibly unitary elasticity of demand, even if nominal purchases are constant (quantity purchased will rise in inverse proportion to the fall in price).

Why is this issue important for the study of innovation? One reason is that we would like to study the impact of a dollar's investment in R&D in a given industry on productivity in that industry and other industries. With the present method of measurement of computer output, it may appear that a dollar's investment in R&D in the computer and semiconductor industries has a much higher payoff to the firms making the investment, and to the economy as a whole, than a dollar invested in R&D in other industries, such as genetically modified crops or biotech. To the extent that these other industries are using computers and related (hedonically deflated) products to produce their own R&D investment, that cost growth of that R&D may be overstated. The rate of return to R&D investment in these other industries may thus be understated.

Another reason is that the input-output table and the capital flow table (showing investment by type of capital good by industry) are both used as tools to study the transmission of the effects of product innovation of intermediate or capital goods. To produce a comparable series of such tables over time, they must be deflated. If the tables are deflated over the period 1997 to 2002 using the BEA computer deflators, the transmission of semiconductor and computer R&D to other industries will grow extremely rapidly, dwarfing the measurement of the transmission of R&D in other industries.

In the models developed by Inforum, we substitute for the BEA computer deflator and semiconductor deflator a constant deflator, which enables us to construct reasonable time series of constant price accounts, and construct useful measures of capital input and productivity growth.

However, we are not entirely happy with this approach, and agree that the proper deflator probably should be declining over time. There are several arguments adduced above and in other literature on the computer deflator, that suggest that a relevant measure should not be a function of a linear combination of measurable characteristics. Some recognition should be given to the declining marginal value of those characteristics as they become much cheaper. Otherwise we will tend to find computers not generating much TFP growth in other industries, but showing plenty of computer TFP growth.

Shift emphasis from real value added to real gross output as a measure of industry growth.

Real value added (RVA) is the preferred measure used by BEA and other international statistical agencies to ascertain the contributions of different industries to overall GDP growth, as well to determine the relative growth rates of different industries. RVA is used in many analyses of industry productivity growth.

However, there is no fundamental agreement on the meaning of RVA, or its price. Although nearly every major statistical organization in the world computes it, few have attempted to define rigorously what it measures. Some equate RVA with real output, though strictly speaking, it is not that. Some view RVA as a measure of the purchasing power of value added, but that it not how it is generally calculated. The method of calculation recommended by the SNA, and used by BEA for most industries, is double deflation. BEA has been innovative in using this method, by calculating real value added as a chained quantity index of real output less real intermediate inputs. In theoretical literature (Sato, Moyer) this calculation of RVA is shown to measure a subaggregate of a production function, consisting of the value added inputs.

If certain separability conditions do not hold, it is not clear what the double-deflated RVA is measuring. In industries that experience large relative price changes, large changes in factor shares, or large changes in the value of inputs relative to output, the quantities and prices yielded by double deflation can often be non-intuitive, to say the least. Examples of where we find severe problems with the measure are in the crude petroleum and computer industries. A 1987 book by Jorgenson, Gollop and Fraumeni found the separability conditions were violated in many industries, including those two industries.

This topic is important to the study of innovation for many of the same reasons as the computer deflator: 1) to ascertain the contribution of R&D to the productivity growth of various industries, we should use a well-defined and economically sensible measure of real output; 2) for the study of transmission effects of innovation, we need to correctly allocate the sources of growth in the economy.

I applaud the plans for the New Architecture of the National Accounts, described in the comments by Jorgenson, and at more length in the Jorgenson and Landefeld volume. However, the U.S. has not yet published a set of consistent constant price accounts, consistent with a constant price input-output framework. With much smaller resources, Inforum has developed such a set of accounts, based on published BEA data. Although they are probably only a mere shadow of what the BEA will ultimately produce, we have already encountered in their construction several problems that BEA may pause to consider:

1. Hedonic deflators, constructed in a single industry framework, as a linear function of measurable characteristics, will result in constant price accounts where those deflators are the main factors explaining productivity and input coefficient growth (decline) into computers.
2. These deflators are also problematic for prices constructed according to an IO identity, where output price is a weighted combination of input prices and value added per unit of output. Over the late 1990s, for example, the costs of most inputs into computers, including semiconductors, were not falling as rapidly as the computer price. To obtain the BEA computer deflator by the IO identity, we must assume that all input-output coefficients, and labor and other value added coefficients are falling rapidly, or else that the "price" of value added is declining rapidly.
3. A decision should be made as to whether the constant price IO tables should sum up the column to output in real terms. This may be a Fisher index, as is used for real value added, but then the meaning of a real IO coefficient must then be redefined from its traditional definition (deflated input divided by deflated output). Leontief regarded the column sum of real IO coefficients as meaningless, and therefore did not require deflated input-output "flows" to sum to output down a column, in years other than the base year. However, Richard Stone took the approach that columns sums of IO tables must sum to output in both real and nominal terms. This approach then suggests to derive RVA as a residual, and this method has been used so far by the SNA and BEA. The problem with this approach can be seen more starkly if we ignore indirect taxes, and treat labor as another input, with its price being the compensation per hour worked. Then real value added becomes real profit-type income (or gross operating surplus) and represents the amount that profit would have been if input prices (including labor) had been those of the previous year, but input quantities are those of the current year. The meaning of such a measure is not at all clear. We would rather not use it to study the effects of innovation, or measure industries' relative contribution to growth. It is not clear to me what is meant by the recommendation in the

"Architecture" to measure TFP as the ratio of GDP to GDI in constant prices. However, I would disagree with the use of a real GDI by industry to study total factor productivity, as real value added measure is distorted in the crude petroleum, computer and many other industries.

4. Another problem encountered when trying to build constant price IO tables is to reach consistency between IO measures of personal consumption and investment and NIPA measures. For example, the published NIPA show nearly 100 categories of personal consumption expenditures. The PCE bridge, published with the benchmark IO table, and in more aggregate form from 2002 to 2005, shows the composition of those personal consumption categories by input-output commodity. The input-output commodities for domestic use have individual deflators, which can be constructed by weighting the domestic output deflators with import deflators for those commodities, using as weights the share of imports in total use. Detailed (benchmark level detail) annual PCE bridges can be estimated in nominal terms, using the information BEA makes publicly available, and making gross assumptions (using benchmark bridge shares) to try to reproduce the data that BEA has been estimating internally. However, to deflate these PCE bridges to constant prices, one is immediately faced with the conflict between the rule of one commodity price across the row, and matching the published NIPA PCE deflators by category. We see three alternatives: 1) using the IO commodity prices and bridge table weights to create our own price index by PCE category (we've tried that, and are not happy with it); 2) matching the BEA NIPA PCE deflators by scaling the bridge up to the NIPA in constant prices, resulting implicitly in a different price for every cell of the table (not intuitively satisfying); and 3) using some existing rows of the bridge (wholesale and retail trade margins?) or a new discrepancy row to enforce nominal and real consistency with NIPA. Until one has seriously tried to deal with this problem, it sounds easy. A similar problem is encountered in developing deflated capital flow tables (very useful for deriving real capital input measures!), although now we have two BEA constraints to match: 1) the real and nominal data on equipment and software investment published in NIPA table 5.5; and 2) the real and nominal investment series in the BEA *Fixed Assets* data, which agree in principle with the NIPA table. Both of these BEA accounts show the investment data by commodity in purchasers prices, so one may implicitly be using a different "price" for wholesale and retail margin, depending on which asset it is attached to.

5. The problem mentioned in 4 above is exacerbated by using an aggregate level of detail, such as the BEA 65. At this level, output mix differences in different intermediate or final use columns imply that there should not be one price across the row. In fact, reaching consistency with the constant price NIPA accounts with the traditional IO assumption of a single price across the row is already difficult at the detailed benchmark level. For example, the growth rates of prices for aircraft shown in the NIPA investment, government defense, and export accounts are all different, and this is most likely due to the different types of aircraft comprising each of these components of final demand.

While the above difficulties are not immediately germane to issues of innovation and productivity, and transmission of innovation, they are relevant to the development of the New Architecture, which should better be able to address the study of these issues. I wish the BEA success in the development of this new architecture.